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The yielding of greenhouse tomato grown in straw and rockwool substrates

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ABSTRACT

The experiment with tomato 'Cunero F_1' was held in a greenhouse where plants with 23 fruit clusters were grown in substrate consisting of rye straw, wheat straw and rockwool. A closed system of fertigation without re-circulation was applied. The plants grown on all kinds of substrates were fertilized with the same nutrient. Usefulness of rye straw and wheat straw as substrates for greenhouse tomato cultivation has been established. The comparison of the yield of plants grown in straw with the yield of plants grown in rockwool showed no substantial difference. The content of dry weight, vitamin C and sugars in fruit has been differentiated to a small extent. After 34-week vegetation period (at the end of the experiment) about 70% of straw has been mineralized. In the period of vegetation the content of mineral N, P, K, Ca, Mg, S-SO_4 and the content of pH and EC in the substrates tested have been differentiated only to a small extent.

INTRODUCTION

The evaluation of substrate usefulness for plant growing in greenhouses is made in many respects. Apart from the crop obtained, the things to be considered are: crop quality, cost of substrates purchased as well as substrate use or its utilization as process waste after growing finishing. Thus, various materials are used for substrate preparation such as peat, pine bark, sawdust, coco-fibre and cacao shell (Lis-Krzyścin 1996, Nurzyński 1996, Rumpel 1998). The use of fertigation in greenhouses enables growing plants in substrates made of rockwool, polyurethane foam, perlite, vermiculite, sand (Gizas et al. 2001, Nurzyński et al. 2003, Inden and Torres 2004).

Straw is an interesting organic substrate in greenhouse growing. In horticulture straw has been used for a long time. It is added to soil in the form of mulch mainly in field crops cultivation (Shukry et al. 1999, Cerne et al. 2000, Hallidri et al. 2001, Gebologlu et al. 2002). Moreover, straw can be added to composts and substrates (Garedal and Lundegardh 1998). In the greenhouse, straw in the form of big ballots was used as a heating material. Ballots were dug up completely or in halves, then peat and compost were put on the ballots' surface and the plants were grown (El-Aidy et al. 2003). The research regarding straw use as substrate in the amount similar to peat and rockwool has been quite recent. The results are promising in respect to growing in pressed straw and growing in mixture of straw and coniferous trees' bark and sawdusts (Dyśko and Stępowska 2002) as well as in cut straw placed in appropriate containers (Nurzyński 2002).

The aim of the research was a comparison of greenhouse tomato growth and yielding in substrate consisting of rye straw, wheat straw and rockwool with the same kind of fertilization applied.

MATERIAL AND METHODS

The experiment with tomato variety 'Cunero F_1' took place in the years 2003 (4.03-12.11) and 2004 (2.03-13.11) in a greenhouse where plants with 23 fruit clusters were grown. The substrates were: 1/ rye straw cut into pieces, 2/ wheat straw cut into pieces, 3/ rockwool. A closed system of fertigation was applied, without re-circulation, with about 20% overflow liquid feed. The straw cut into pieces (their length 2-3 cm) was placed in polyethylene boxes, of 15 dm^3 volume, i.e. the same as slabs of rockwool. The experiment was carried out in a completely randomized way and was repeated seven times. The repetition of the experiment was done in a box/mat with two plants. In calculation for 1 m^2 of greenhouse surface 2.4 plants were grown. All the plants were fertilized with identical amount of the same fertilizer at analogous time. On sunny days the fertigation system turned on 9-10 times per day supplying each plant altogether with about 2.5 dm^3

of nutrient solution (Table 2). For chemical analyses of nutrients, EC and pH in substrates, solution from the root area was taken with a syringe. Mineral nitrogen ($N\text{-}NH_4$ + $N\text{-}NO_3$) was marked with Bremner distillation method, phosphorous – colorimetrically K, Ca and Mg with flame method ASA (Perkin-Elmer). In fruit, dry weight and vitamin C were marked with Tillman's method and sugars according to Schorl-Regenbogen. For analyses samples of 10 ripe fruits were taken of 7-9 cm diameter, weighing each time 20 g of fresh mass in three repetitions. In each year of the experiment the substrates were analyzed 10 times, and the fruit – twice in 15 and 28 week of the cultivation period (the 5^{th} and the 15^{th} fruit clusters). Due to negligible differences in results from the two years, average values from the years 2003 and 2004 were indicated in the tables.

Bombus terrestris used for plant pollination Greenhouse Whitefly (*Trialeurodes vaporariorum*) was biologically controlled with *Encarsia formoza*.

RESULTS AND DISCUSSION

Throughout the whole period of the vegetation the plants in all substrates grew in a right way, no leaf deformation was noticed, there was no blossom-end rot of fruit. The fruit crop obtained from 1 plant (about 16.0 kg) is estimated to be high. Having calculated it into 1 m^2 of greenhouse area it amounts even to 40 kg of fruits. Piróg (1999) obtained similar results.

Straw decomposes mainly by mineralization and CO_2 is liberated throughout the whole period of the plants vegetation. After the experiment was ended, about 30% of undecomposed straw was left. Beneficial influence of enriching atmospheric air with CO_2 has been proved many times (Li et al. 1999, Pork and Lee 2001). It can also be assumed that plants in rockwool substrate benefited from CO_2 liberated from decomposed straw.

The difference in the crop obtained from plants grown in substrate consisting of rye straw, wheat straw or rockwool was negligible. Similarly, the content of dry weight, vitamin C and sugars in fruit differed only slightly. No significant differences were observed in the crop of early fruit (after 22 week growth) depending on the kind of substrate tested (Table 1).

During the period of vegetation the contents of nutrients in substrates were marked many times. In Table 2 averages for the years were quoted. Little differentiation of $N\text{-}NH_4$, $N\text{-}NO_3$, P, K, Ca, Mg, $S\text{-}SO_4$ and pH and EC values in substrates tested is remarkable despite the fact that straw contains (in % dry weight) about 0.75-N, 0.05-P, 1.15-K, 0.20-Ca, 0.04-Mg. In the interpretations of these relations 20% surplus of the fertilizer applied (the so-called overflow) during plant vegetation is taken into account. It is also worth highlighting that the chemical content of fertilizer suggested for straw substrate (Table 2) is also appropriate for tomato grown in rockwool substrate.

Table 1. The effect of medium type and cultivation period on the yield and quality characteristics of tomato fruits, mean from 2003 – 2004

Medium	Yield (kg plant^{-1}) Cultivation period 22 weeks	34 weeks	Dry matter (%)**	Vitamin C (mg 100g^{-1} f.w.)**	Total sugars (% f.w.)**
Rye straw	10.31 a*	16.25 a	5.80 a	16.12 a	3.03 a
Wheat straw	9.95 a	15.48 a	5.60 a	15.65 b	2.92 a
Rockwool	10.35 a	15.91 a	5.70 a	16.50 a	2.97 a

*Values marked with the same letter do not differ significantly at p = 0.05
**Means of 4 terms of analyses from 15 and 28 week cultivation period

Table 2. The effect of medium type on the nutrient content in growth medium (mg dm^{-3} of solution from the root environment), nutrient solution and water (mg dm^{-3}) (mean of 20 terms of analyses from two years of studies)

Medium	N-NH_4	N-NO_3	P	K	Ca	Mg	S-SO_4	pH_{H2O}	EC (mS cm^{-1})
Ray straw	40 a*	335 a	121 a	424 a	274 a	108 a	117 a	5.8-6.4	3.2 a
Wheat straw	49 a	359 b	119 a	432 a	248 a	106 a	127 a	5.7-6.3	3.4 a
Rockwool	37 a	367 b	112 b	379 b	252 a	104 a	126 a	5.0-5.5	3.4 a
Nutrient solution	56	228	96	328	130	56	71	5.1-5.7	2.4
Water	-	4	3	5	95	10	8	7.1-7.4	0.7

*Note: see Table 1

The research results indicate that straw (both rye and wheat) is a very good kind of substrate for greenhouse tomato. After mineralization it supplies plants with CO_2, and when the growing is completed there is no problem with its utilization as process waste (unlike in the case of rockwool). Straw can be ploughed in the field and added to compost. Straw substrate is also much cheaper than rockwool substrate.

It is important where samples from substrate are taken for analyses, as it influences the results and their interpretation. In the case of straw substrate solution from the root area for chemical analyses is taken in several places, which can be done easily and precisely. Sonneveld and Voogt (2001) stress that salt distribution in most fertilizing systems is uneven.

Most vegetables and ornamental plants are grown in greenhouses in peat and rockwool substrates. These are very good substrates, however Riviere and Caron

(2001) claim that their use in the nearest future will decrease. Therefore straw, due to the fact of fulfilling conditions of very good substrate seems to stand a chance to be used more frequently. Moreover, taking into account obtaining of straw and its utilization as process waste, straw can be considered fully ecological substrate.

CONCLUSIONS

1. The usefulness of rye straw and wheat straw (cut into pieces) as substrates for greenhouse tomato has been proved. As compared to rockwool no substantial difference in yielding has been indicated.
2. The content in fruit of dry weight, vitamin C and sugars has been differentiated to a small extent.
3. After 34 week vegetation period (at the end of the experiment) about 70% of straw has been mineralized.
4. In the period of vegetation the content of mineral N, P, K, Ca, Mg, S-SO_4 and the content of pH and EC on the substrates tested have been differentiated only to a small extent.

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PLONOWANIE POMIDORA SZKLARNIOWEGO UPRAWIANEGO W PODŁOŻU ZE SŁOMY ORAZ WEŁNY MINERALNEJ

Streszczenie: Doświadczenie z pomidorem 'Cunero F_1' przeprowadzono w szklarni uprawiając rośliny na 23 grona w 3 podłożach: z rozdrobnionej słomy żytniej, słomy pszennej oraz w wełnie mineralnej. Zastosowano zamknięty system fertygacji bez recyrkulacji, a wszystkie rośliny nawożone były pożywką o jednakowym składzie. Stwierdzono przydatność pociętej słomy żytniej oraz pszennej jako podłoża dla pomidora uprawianego w szklarni, gdyż w porównaniu z wełną mineralną nie wykazano istotnych różnic w plonowaniu. Zawartość suchej masy, witaminy C i cukrów w owocach była w małym stopniu zróżnicowana. Po 34 tygodniach wegetacji (zakończenie doświadczeń) około 70% słomy zostało zmineralizowane. W okresie wegetacji zawartość N_{min}, P, K, Ca, Mg, $S\text{-}SO_4$ oraz wartość pH i EC w badanych podłożach była mało zróżnicowana.

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